August 25, 2006

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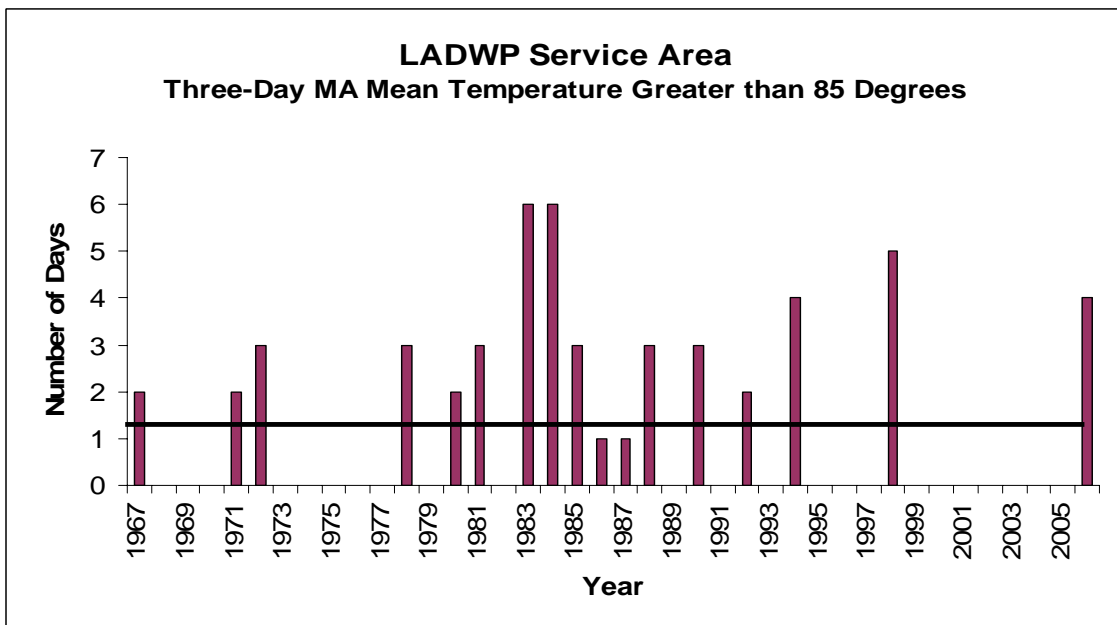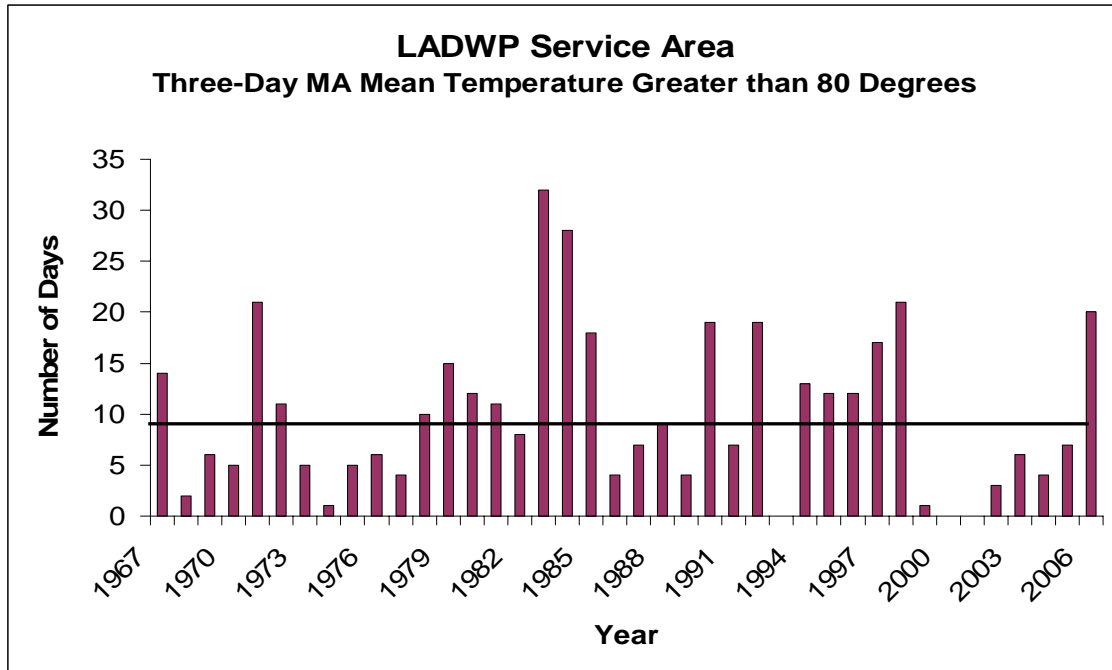Subject: Committee Workshop on the July 2006 California Heat Storm

1. How does the July 2006 heat storm sequence compare to previous periods of hot and humid summer weather in California and the West?

LADWP analyzed forty years of temperature data for the service area. Temperature is a linear combination of three weather stations located at the Civic Center, Woodland Hills and LAX. We then calculated the three-day moving average temperature. Heat storm was defined as an event where the daily mean temperature exceeded 85 degrees. Each heat storm was further measured by two factors – intensity and duration. Intensity is defined as Base 85 Cooling Degree Days. Duration was measured as consecutive days when mean temperature was 80 degrees or above. We then ranked each heat storm by its intensity and its duration. The final ranking was based on the product of the intensity and duration ranks.

Heat Storm Event	Start	End	Intensity	Duration	Rank
July-06	7/15/2006	7/29/2006	6.7	15	1
August-98	8/29/1998	9/4/1998	12.6	7	2
September-71	9/8/1971	9/15/1971	5.2	8	3
August-94	8/11/1994	8/18/1994	3.3	8	4
August-83	8/6/1983	8/18/1983	0.6	13	5
September-84	9/4/1984	9/10/1984	5.2	7	6
September-88	9/3/1988	9/7/1988	5.4	5	7
August-92	8/11/1992	8/21/1992	0.9	11	8
September-78	9/24/1978	9/30/1978	2.6	7	9
July-72	7/27/1972	8/2/1972	3.3	7	10
September-84	9/15/1984	9/21/1984	2.4	7	11
July-85	7/1/1985	7/5/1985	3.0	5	12
September-83	9/10/1983	9/15/1983	2.2	6	13
August-67	8/29/1967	9/3/1967	1.8	6	14
June-81	6/15/1981	6/19/1981	1.0	5	15
July-80	7/29/1980	8/3/1980	0.3	6	16
August-81	8/26/1981	8/29/1981	0.6	4	17
October-87	10/2/1987	10/6/1987	0.2	5	18
July-90	7/12/1990	7/15/1990	0.2	4	19
June-90	6/26/1990	6/29/1990	0.1	4	20

The July 2006 ranked as the most extreme in our database having the longest duration and second highest intensity. The 1998 event was second most extreme event ranking the highest in intensity. Interestingly, the last three heat storms ranked in the top four extreme events which in the minimum does not disprove the hypothesis that the weather is beginning to show higher variability.

Another tidbit that can be drawn from the analysis concerns the frequency of the heat storm event. The last ten years have been relatively benign compared to the previous thirty.

LADWP Service Area
Three-Day MA Mean Temperature Greater than 80 Degrees

LADWP Service Area
Three-Day MA Mean Temperature Greater than 85 Degrees

Simply by just eyeballing the above charts, one can make a mean reversion argument, that more heat storms will occur in the next ten years than occurred in the past ten. Given that we have the global warming hypothesis as a potential catalyst for more events, it may be prudent to prepare for more frequent heat storms in the planning horizon.

2. **How important is it to understand weather patterns within different regions in California and across the West? Demand and supply patterns within different regions in California and across the West? How can this best be accomplished?**

This question is analogous to adding emerging market stocks into an investment portfolio. The stocks are added for diversity and to reduce risk. Yet, in times of crisis, historical returns have tended to become more correlated and one loses the diversity in the portfolio right at the moment it is most needed.

In California, the LADWP service area peak is not perfectly coincident with the CAISO peak. The LADWP peak most likely occurs in late August or very early September. CAISO models their peak to occur in mid-September. Yet in the last two extreme weather events in September 1998 and July 2006, the two system peaks were coincident with each other.

The proper question for a regional study is to ask how system diversity changes over different ranges of weather. The initial study would be to test the hypothesis whether or not during extreme weather events the regional power system loses diversity.

The Western Electricity Coordinating Council collects data from all the western region electric utilities. Given their data repository, it might be the first place to ask such questions.

3. **How should we factor heat and summer humidity effects into future load forecasts?**

Heat and humidity are already factored into the LADWP forecast. We construct a weather variable that takes into account temperature, humidity and heat build up. LADWP builds a probability distribution on the weather variable using the central tendency theorem based on historical peak day temperatures.

Historical Peak Day Weather
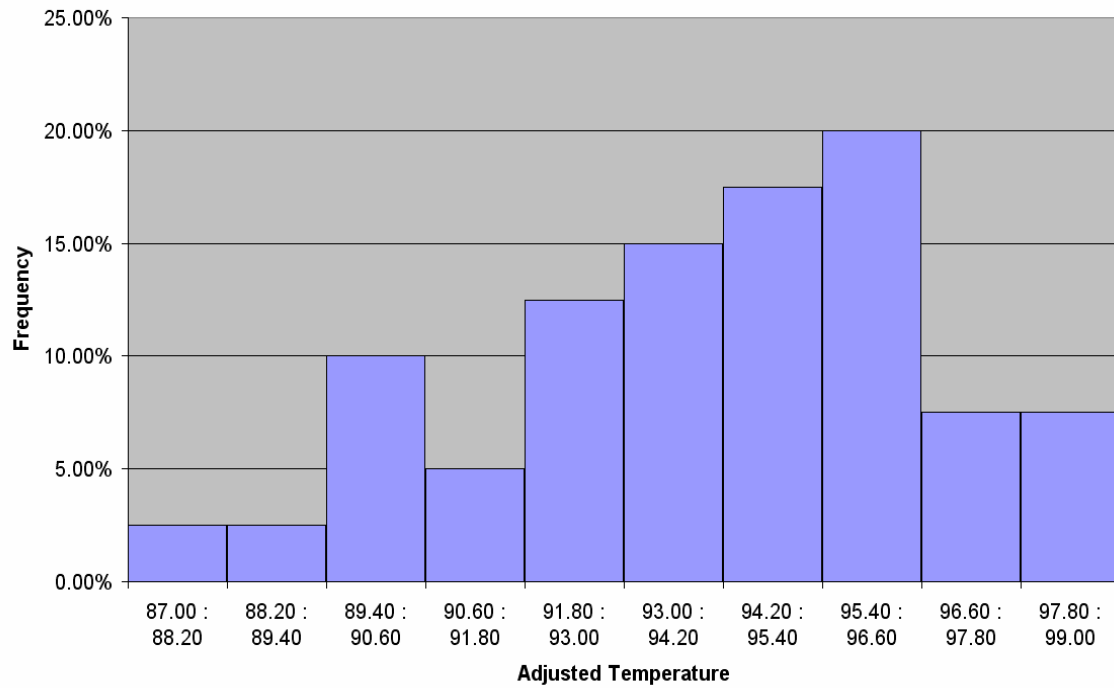
Peak Day Temperature Estimates Using Central Tendency Theorem
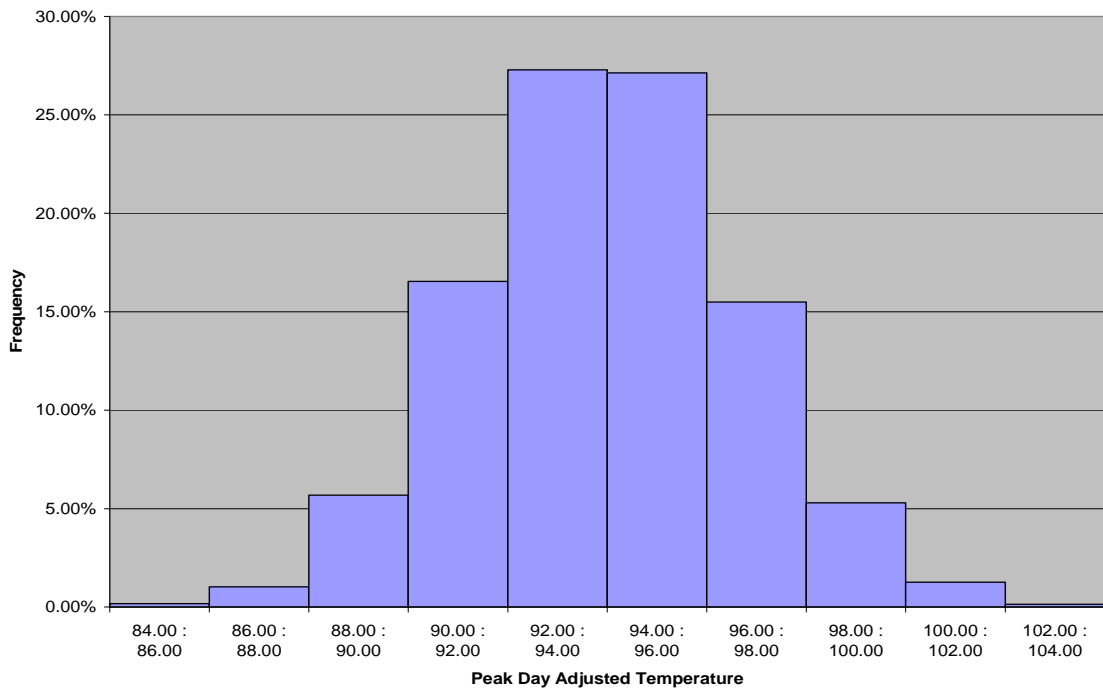
Once you have the distribution, you can calculate the probabilities of a temperature occurring on the peak day. As an alternative, you can calculate the probability of a temperature occurring on the peak day using Monte Carlo techniques on the actual data.

**Monte Carlo Peak Day
Temperature Estimates**
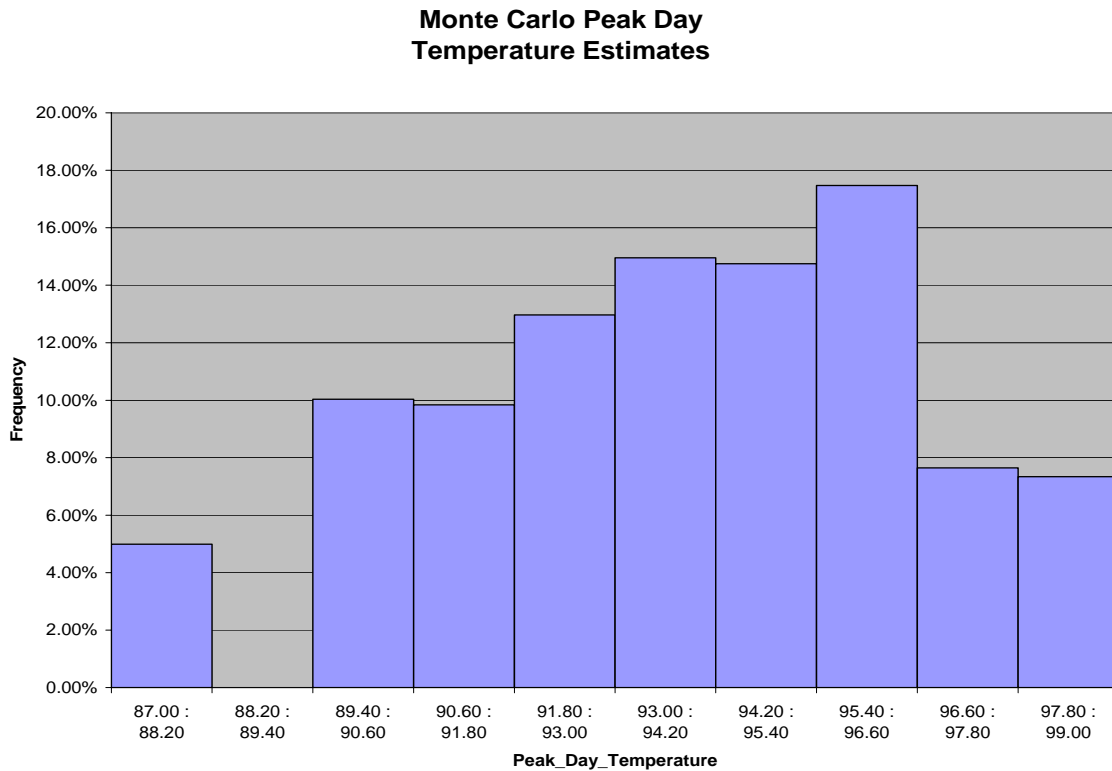
LADWP uses the central tendency technique.

4. Will forecasting methods or assumptions need to change to accommodate the possibility of more variability in California's future weather?

The peak demand model that LADWP uses is based on the megawatt response per degree function. LADWP assumes that megawatt response per degree is non-linear and it uses a spline methodology to capture the changes in the curve. LADWP has tested various methodologies over time and finds the results of the spline method satisfactory.

Although the model is found to be satisfactory, we will be analyzing some inputs and assumptions based on the July 2006 Heat Storm. Two major ones come to mind.

First, the weather input is built around the peak occurring during a three-day heat storm. In the July event, two of the three climate zones basically followed this pattern. However, in the San Fernando Valley, the third climate zone, maximum temperature averaged nine degrees above normal for a period of thirty-six days. Therefore LADWP will be testing adding additional duration into its weather input while continuing to use the spline methodology in peak demand forecasting.

Second, at LADWP we assume that demand for electricity can reach saturation level and that there is ceiling on the system demand level that can be reached in any given year. We model the ceiling in the spline methodology by gradually lowering the MW response

once temperatures exceed 95 degrees. For 2006, it was the Load Forecaster's opinion that the ceiling for 2006 was 6000 MW. This opinion was a sanity check when we published our hot case peak of 5955 MW for 2006. Actual peak was 6102 MW which was beyond both the results of the peak demand model and the forecaster's opinion. Ex ante, the probability of reaching 6102 MW based on the peak demand model was 0.4%.

The saturation assumption is based on the 1998 event when demand significantly leveled off beginning around 13:00 hours. The pattern was unusual because on most summer weekdays the curve levels off at 15:00 hours.

NEL Peak Day Comparisons
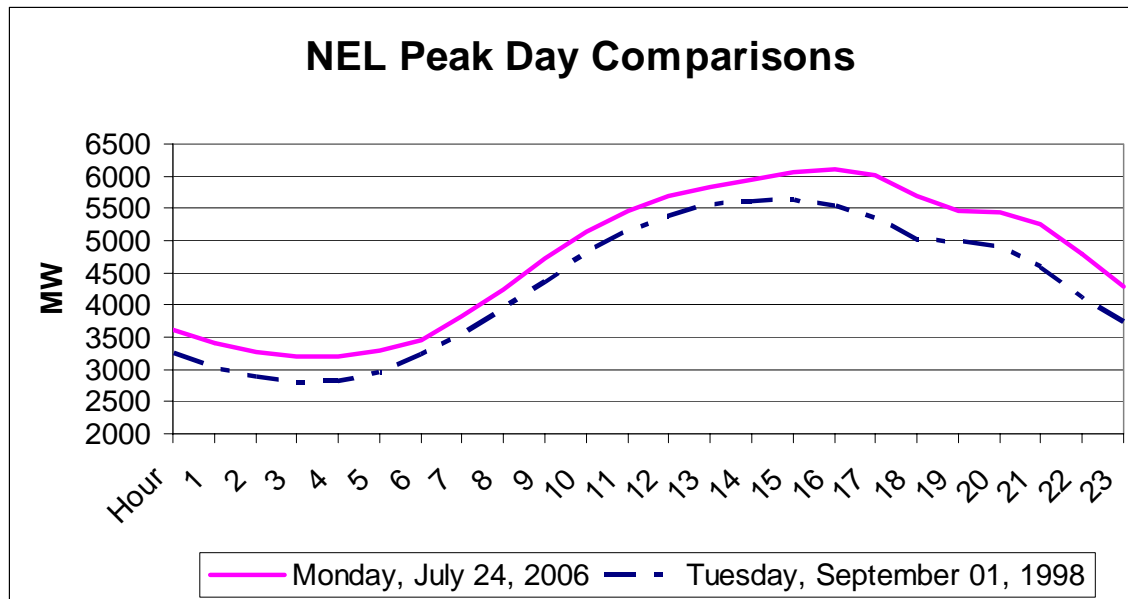
Ex post the July 2006 heat storm, analysis has shown that the MW response per degree at the temperatures above 95 degrees was 168 which compares unfavorably to the ex ante forecast of 72 MW per degree. However, it is hard to imagine that if the temperature was two degrees higher on July 24 that System Peak would have reached 6440 MW. It is our belief that at 6102 MW, the System was very near its saturation level.

Forecasting saturation or the ceiling is a Load Forecaster's Moby Dick. It is rarely seen so not much data is gathered. At LADWP, we have tried to develop methodologies to forecast the saturation point rather than rely on our judgment. Methods that have been looked at include the use of Extreme Value distributions and Monte Carlo methods. As of yet, we have not been successful in our search. Our suspicion is that the techniques being used in quantitative finance to model fat-tailed events will eventually have some use for peak demand modeling.

Utilities across the nation had difficulty forecasting the peaks created by the July Heat Storm. An article in Platts Electric Utility Week questioned whether load forecasting is keeping up with changes in consumer consumption patterns.

ISO New England was "continually underforecasting" demand last year, Giudice observed. That has changed, and in other jurisdictions around the country there is an "awakening" of a new appreciation for the higher peak load curves. "The change in usage is more significant than what the modeling has been able to appreciate," with customer usage outstripping appliance efficiency gains and other demand-dampening factors, Giudice said.

LADWP has experienced a similar phenomenon. The Load Research group at LADWP found that non-coincident residential demand grew by 30 percent between 1998 and 2006. Meanwhile residential sales growth has only been 10 percent.

However there are limitations on just accurate forecasts can become. One limitation is the availability of accurate economic drivers with which to build models. For example, to return to the residential sector, where the current problem seems to lie, LADWP uses personal income as a proxy for consumer spending in its residential sales model as an economic driver. An April 17, 2006 article in BusinessWeek argued that the traditional relationship between consumption and personal income is changing.

Perhaps most important, a key difference between now and past business cycles is the increasing role of household wealth, measured as the value of assets minus liabilities. In the past three years, the relationship between income and spending – historically, one of the tightest in economics – has weakened considerably mainly because the net worth of households scored the largest three-year growth on record. To a great extent, wealth gains have supplanted income growth as a key support under spending.

In fact, at LADWP the residential model has been under-forecasting sales for the past two years. One potential anomaly is that as the relationship between personal income and spending reverses course and strengthens, perhaps due to the settling of the housing markets, the LADWP models will tend to over-forecast growth in residential sales.

Forecasting methods will adapt as new information is acquired but as long as the nature of electric consumption keeps changing there will never be perfect understanding of what the future holds in store.

5. **How could electricity load forecasts better accommodate the imprecise nature of weather forecasting?**

Long-run forecasts used for the purposes of financial, generation, transmission and distribution planning should be independent of weather forecasting. The methodology of incorporating weather sensitivity cases into the forecast is sufficient for these purposes.